Chemicals in Drinking Water

Grades

High School

Subjects

Science (Chemistry)

Type of Lesson Plan

Lab

Suggested Duration

Two class periods

Materials

- "Drinking water" solution
  - Distilled water
  - NaCl – to represent a contaminant
  - Other non-hazardous soluble elements or inorganic compounds as you choose
- Graduated cylinders
- Burners or hot plates
- Ring stands if using burners
- Matches if using burners
- Oven or dehydrator
- 1,000 ml beakers
- 250 ml beakers
- tongs
- hot pads
- scales
- EPA's MCL list (http://www.epa.gov) or (http://www.epa.gov/safewater/mcl.html) overhead, focus on inorganics
- Copies of lab sheet
- Overhead of Consumer Confidence Report from your Public Water System

Objectives

TLW…

- Separate contaminants from a "drinking water" solution and accurately determine the mass of the contaminant per unit volume of water.
- Compare the concentration of their contaminant to the EPA drinking water standards in order to determine if the contaminant poses a threat to human health.
- Explain the adverse health effects of their contaminant, as well as sources for the contaminant.
- Identify and understand methods of treating or removing the contaminant from drinking water.

Set

One option for an introduction to this lesson is a field trip to a water treatment plant (preferably drinking water, but wastewater is valuable as well). Alternatively, a visit to an analytical laboratory could be substituted. An additional realistic introduction to this lesson would be to invite an analytical chemist as a guest lecturer.

Have the students pick up and preview a lab sheet as they enter the class.

Ask the class to hold up their hands if they think their drinking water is safe for consumption. Ask those that do not raise their hands why they think the drinking water in your town may not be safe. Many will respond that the water contains various types of pollution. Ask them if they know of any specific pollutants that might be in drinking water and if they know the sources of the pollution. Ask if drinking water must be totally absent of contaminants in order to be considered safe.

Show the overhead of the EPA's MCLs for drinking water. Point out the extremely small quantities of contaminants that can be present in water, for it to be considered unsafe to drink. Inform the student that they will be engaged in a lab designed to test the quality of a hypothetical sample of drinking water.

Instructional Input

Go over the lab procedure with the students.

Conduct the lab.

See "Closure."

Guided Practice

See the lab sheet.

Evaluation

See the lab key. You may assign point values as you see fit.

Closure

Obtain a copy of the Consumer Confidence Report from your local Public Water System. Analyze the report with the class (overhead) and compare the results of water sample analysis with the EPA Drinking Water Standards. Discuss any areas of potential concerns or MCL violations. What are some of the potential contaminant sources, health effects of contaminants in your drinking water, and treatment methods for any contaminants in your water? (http://www.cyber-nook.com/water/concerns.html is a good place to start to identify treatment methods)

Resources

1. Fill an appropriate number of 1,000-ml beakers with 1,000 ml of distilled water. The number of beakers should equal the number of lab groups you will have in your class. Label each beaker with a unique code.
2. Measure out a given amount of "contaminant" and dissolve in the beaker of water. Make sure you keep a table of beaker codes, concentration of contaminant (mg/L), and the type of contaminant you are simulating for each beaker.
3. Cover to prevent evaporation if leaving over night.
4. Make sure you have the requisite sets of lab materials (see lab sheet)

Most scales available to schools will not be sensitive enough to measure milligrams of the solutes you add to the water. I suggest using 0.5 g or more of solute (NaCl or sugar works well) if your scales can accurately and precisely measure this amount. **Do not merely use your school's tap water!** Your equipment will not be sensitive enough to measure any contaminants that might be present.

Keep in mind that the students will take the tare mass of their empty beakers, pour in the "drinking water," and boil the water. **Be careful not to boil all the water out.** This could cause the beaker to break. Instead boil the water until there is a very small amount left and place the beaker in the oven or dehydrator overnight. The remaining water will evaporate. The following day, weigh the beaker and contaminant in order to determine the mass of the contaminant before calculating its concentration in the water. Of course the concentration will be many orders of magnitude higher than what would normally be found in safe, and even unsafe, drinking water. This is addressed in the follow up lab questions. The solute/contaminant you use is up to you; you may even want to use different kinds. The important thing to remember is that you are simulating actual drinking water contaminants. It would not be safe to use mercury, lead, or arsenic; consequently it is suggested that teachers substitute safer contaminants. These substitutions will represent the more dangerous contaminants found in drinking water.

"Chemicals in Drinking Water" Lab

Name_____Period_____Date_____

Materials

- "Drinking water" solution in a 1,000 ml beaker
- Empty 250 ml beaker
- Burners or hot plates
- Ring stands if using burners
- Matches if using burners
- Tongs
- Graduated cylinder
- Hot pads
- Scale
- Calculator
- Safety goggles

Procedure

1. Using a graduated cylinder, collect 100-ml beaker of "drinking water" from one of the 1,000-ml beakers. Record the type of contaminant in your water in Table 1.
2. Collect a 250-ml beaker and measure its mass using a scale. Record its mass in Table 1.
3. Carefully pour all of the drinking water into the empty beaker. Be careful not to spill.
4. Place the beaker with the drinking water on the hot plate or ring stand.
5. Turn the hot plate control knob to the setting provided by your teacher. If using a burner and ring stand, light your burner and set the flame to the level your teacher shows you.
6. Allow the water to come to a light boil. DO NOT allow your water to boil vigorously as you will loose some of your contaminant to splattering.
7. Begin working on questions 1,2,7,8 and Extra Credit while monitoring your solution.
8. When very little water is left, turn off your hot plate or burner.
9. Using a hot pad or tongs, carefully move your beaker and place it in the oven or dehydrator overnight.
10. The following day, place the beaker on the scale and record the mass of the beaker and contaminant in Table 1.
11. Calculate the mass of the contaminant and record the amount in Table 1.
12. Calculate the concentration of your contaminant and record the results in mg/L in Table 1.
13. **SHOW YOUR WORK** to the right of Table 1.

Table 1

Contaminant	
Mass of empty 500-ml beaker in **g**	
Mass of beaker and Contaminant in **g**	
Mass of the contaminant **in mg (pay attention to units)**	
Volume of drinking water in **L**	**0.1 L**
Concentration of the Contaminant in **mg/L**	

Questions Name_____ Period_____ Date_____

1. What was your contaminant? _____

2. Check the EPA Drinking Water Standards and record the Maximum Contaminant Level (MCL) for your contaminant.
   _____

3. What was the concentration of your contaminant in your drinking water? _____mg/L

4. Does this concentration exceed EPA Drinking Water Standards? YES or NO

5. If your concentration is above the MCL, by how much is the MCL exceeded?
   _____mg/L

6. Look at the amount of contaminant in your beaker and compare that with the mass. Now consider the MCL for your contaminant. What does this tell you about the EPA Drinking Water Standards?

7. What are the health effects of your contaminant?

8. What are some of the sources of your contaminant? (Where does is come from?)

Extra Credit:

How can drinking water be treated to remove this contaminant? Cite your source.

"Chemicals in Drinking Water" Lab Name__**Example Key**___Period__

Materials

- "Drinking water" solutions in a 1,000 ml beaker
- Empty 250 ml beaker
- Burners or hot plates
- Ring stands if using burners
- Matches if using burners
- Tongs
- Hot pads
- Scale
- Calculator
- Safety goggles

Procedure

1. Using a graduated cylinder, collect 100 ml of "drinking water" from one of the 1,000 ml beakers. Record the type of contaminant in your water in Table 1.
2. Collect a 250-ml beaker and measure its mass using a scale. Record its mass in Table 1.
3. Carefully pour all of the drinking water into the empty beaker. Be careful not to spill.
4. Place the beaker with the drinking water on the hot plate or ring stand.
5. Turn the hot plate control knob to the setting provided by your teacher. If using a burner and ring stand, light your burner and set the flame to the level your teacher shows you.
6. Allow the water to come to a light boil. DO NOT allow your water to boil vigorously as you will loose some of your contaminant to splattering.
7. Begin working on questions 1, 2, 7, 8, and Extra Credit while monitoring your solution.
8. When very little water is left, turn off your hot plate or burner.
9. Using a hot pad or tongs, carefully move your beaker and place it in the oven or dehydrator overnight.
10. The following day, place the beaker on the scale and record the mass of the beaker and contaminant in Table 1.
11. Calculate the mass of the contaminant and record the amount in Table 1.
12. Calculate the concentration of your contaminant and record the results in mg/L in Table 1.
13. **SHOW YOUR WORK** to the right of Table 1.

Table 1

Contaminant	*Chromium (Cr)*
Mass of empty 250-ml beaker in **g**	100 g
Mass of beaker and Contaminant in **g**	100.42 g
Mass of the contaminant **in mg (pay attention to units)**	420 mg
Volume of drinking water in **L**	**0.1 L**
Concentration of the Contaminant in **mg/L**	4200 mg/L

Questions KEY

1. What was your contaminant? ____**Chromium**_____

2. Check the EPA Drinking Water Standards and record the Maximum Contaminant Level (MCL) for your contaminant.

   ____**0.1 mg/L**_____

3. What was the concentration of your contaminant in your drinking water? _**4200**____**mg/L**

4. Does this concentration exceed EPA Drinking Water Standards? **YES** or NO

5. If your concentration is above the MCL, by how much is the MCL exceeded?
   __**4199.9_mg/L**

6. Look at the amount of contaminant in your beaker and compare that with the mass. Now consider the MCL for your contaminant. What does this tell you about the EPA Drinking Water Standards?

   The amount of contaminant left in the beaker appeared to be very small. It looked like a residue or film. Since the contaminant in out water was 420,000 times the MCL, it is obvious that the Drinking Water Standards are very strict. They do not allow for much contamination at all.

7. What are the health effects of your contaminant?

   According to the National Primary Drinking Water Regulation, if the MCL for chromium in my drinking water was exceeded for many years, I could develop allergic dermatitis.

8. What are some of the sources of your contaminant? (Where does is come from?)

   Chromium is found in natural deposits as well as discharge from steel and pulp mills.

Extra Credit

How can drinking water be treated to remove this contaminant? Cite your source.

Activated carbon, ion exchange, and reverse osmosis may be used to treat and remove chromium from drinking water.
http://www.ext.nodak.edu/extpubs/h2oqual/watsys/ae1029w.htm#what

Falls Water Company, Inc. 2006 Drinking Water Report-2005 Sampling Results

Maximum Contaminant Level (MCL): the highest level of a contaminant that is allowed in drinking water.
Action Level (AL): the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Regulated	MCL	Our Water	Range of Detection	Sample Date	Violation	Typical Source of Contaminant
Total coliform bacteria	**2**	**0-2**	**ND-2**	**Monthly**	**Yes**	**Naturally occurring**
Nitrate as N (ppm)	**10**	**3.4**	**0.94-3.4**	**Dec 2005**	**NO**	**Run off from fertilizer**
Lead (ppb)	**15 AL**	**5**	**ND-5**	**Dec 2005**	**NO**	**Corrosive water & home plumbing**
Copper (ppm)	**1.3 AL**	**0.086**	**0.086**	**Dec 2005**	**NO**	**Corrosive water & home plumbing**
Fluoride (ppm)	**4**	**0.3**	**0.2-0.3**	**Dec 2005**	**NO**	**Naturally occurring**
Barium (ppm)	**2**	**0.2**	**0.2**	**Dec 2005**	**NO**	**Naturally occurring**
Arsenic (ppb)	**50**	**7.2**	**1.7-7.2**	**Dec 2004**	**NO**	**Erosion of natural deposits**

n/a: not applicable; **nd**: not detectable at testing limit; **ppm**: parts per million or milligrams per liter; **ppb**: parts per billion or micrograms per liter

*This is an example only. Each teacher can obtain a drinking water report for their specific city/town from their local water company.